STATUS OF RAINBOW TROUT IN THE KANEKTOK RIVER, TOGIAK NATIONAL WILDLIFE REFUGE, ALASKA, 1993-94

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Status of Rainbow Trout in the Kanektok River, Togiak National Wildlife Refuge, Alaska, 1993-1994

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Abstract.–The Kanektok River supports one of the largest sport fisheries for rainbow trout (*Oncorhynchus mykiss*) in southwest Alaska. To monitor stock status, rainbow trout within the wilderness area of Togiak National Wildlife Refuge between river km 28 and 60 were sampled during June-September 1993. Eight hundred twenty-seven rainbow trout ≥ 200 mm were captured by hook and line. Fork lengths ranged from 213-581 mm and ages from scales were 3-10 years. Due to the low number of recaptures, an abundance estimate could not be generated. Comparisons of results from 1993 and 1985-87 indicated that only the length distributions from 1985 and 1986 were not significantly different. The major concern from these comparisons was the absence of large (> 600 mm) fish in 1993. Comparisons of age frequencies among the years indicated that only 1993 was significantly different from the other years, and age at full recruitment to the sampling gear was one year younger in 1993.

To determine seasonal movements, rainbow trout were radio-tagged during August-September 1993 and relocated from aircraft from October 1993-August 1994. Fifteen flights relocated 2-23 of 26 radio-tagged fish with most fish moving less than 10 km throughout the year. The limited movement indicates that the this reach of the river provides important habitat for rainbow trout in all seasons.

Fork lengths of 35 incidentally captured Arctic grayling (*Thymallus arcticus*) and 181 Dolly Varden (*Salvelinus malma*) ranged from 267-443 mm and 216-629 mm, respectively. Scale ages of Arctic grayling ranged from 3-7 years. Otolith ages of a subsample of Dolly Varden ranged from 4-10 years.

The absence of large rainbow trout and the younger age at full recruitment in 1993 indicate that the size and age structures may be changing. Although subsistence and sport harvest appear to be low, and these apparent changes may be attributed to sampling bias, aging error, or natural variation, hooking and handling mortality over several years may have affected the population. It is recommended that monitoring of the population and fishing pressure continue, and the effects of hooking and handling mortality be determined. To satisfy the Refuge objective of conserving fish and wildlife populations in their natural diversity, public use on this portion of the river should not be increased. Arctic grayling and Dolly Varden populations should continue to be monitored as part of the rainbow trout studies.

INTRODUCTION

Rainbow trout (*Oncorhynchus mykiss*) populations in southwest Alaska are world famous and support many sport fisheries (Alaska Department of Fish and Game 1990a). One of the more heavily fished populations in the region occurs in the Kanektok River (Wagner 1991). The earliest sampling of this population was conducted by the Alaska Department of Fish and Game (Department) in 1975 and captured 30 fish (Minard and Dunaway 1991). During the early 1980's sport fishing use-days on the Kanektok River increased dramatically and concern over the status of the rainbow trout population was expressed by local residents and sport fishing guides (Wagner 1991).

Response to this concern resulted in the King Salmon Fishery Resource Office (Office) capturing 26 fish during a preliminary investigation of the population in 1983. Continued concern in 1984 prompted the Alaska Board of Fisheries (Board) to reduce the sport bag and possession limits for rainbow trout from 15 to 10 per day with no more than two fish over 500 mm. In 1985 the Board further reduced the rainbow trout limits from 10 to two fish per day with no size limit. Also in 1985, the Togiak National Wildlife Refuge (Refuge) placed a moratorium on issuing permits to sport fishing guides on the river within the Refuge. The moratorium limited the number of operators to only those whom had operated on the river during and prior to 1984, and client numbers were limited to 1984 levels. Additionally in 1985, the Office began a three year study to evaluate the status of the rainbow trout population. This study determined that the population of rainbow trout was stable, and recommended a conservative approach to management (Wagner 1991).

Although guided sport fishing on the river within the Refuge had been limited through the late 1980's by the moratorium, unguided sport fishing appeared to be increasing (Mark Lisac, U. S. Fish and Wildlife Service, personal communication). In 1990 the Board maintained the bag and possession limits for rainbow trout, but added the restriction that only one fish over 500 mm could be harvested and that only unbaited, single-hook, artificial lures could be used on the portion of the river within the wilderness area of the Refuge (Alaska Department of Fish and Game 1990b). In 1991 the Refuge Public Use Management Plan (U. S. Fish and Wildlife Service 1991) was adopted and applied to areas within the Refuge boundaries. The plan was implemented on the Kanektok River in 1994. The plan maintained the moratorium and attempted to disperse guided use throughout the season. The need to address future unguided use on the river was also noted.

Although rainbow trout have historically composed part of the subsistence harvest in the Kanektok River (U.S. Fish and Wildlife Service 1990), little is known about the numbers of fish harvested. Rainbow trout are seldom targeted, but are captured incidentally in gill nets while local users are fishing for Pacific salmon (*O*. spp.), or while hook and line ice-fishing for char (*Salvelinus* spp.) (Mark Lisac, U. S. Fish and Wildlife Service, personal communication).

In 1992 the Federal Subsistence Board recognized rainbow trout as a valid subsistence species in the non-navigable waters of the Kanektok River within the Refuge. Restricting

the harvest of rainbow trout to non-navigable waters generated concern that subsistence users might be forced to concentrate their harvests within rainbow trout spawning areas. Because no information concerning rainbow trout spawning migrations and locations was available, it was hypothesized that rainbow trout from the navigable portion of the river migrate to small tributaries to spawn. Concentrating the harvest on spawning fish could cause serious harm to the population.

Therefore, as part of a long term monitoring program identified in the Refuge Fishery Management Plan (U. S. Fish and Wildlife Service 1990) and to provide information for evaluation of the Refuge Public Use Management Plan, in 1993 the Office initiated the second in a series of investigations concerning the status of rainbow trout in the Kanektok River. Primary objectives of this study were to: (1) describe the length and age compositions of rainbow trout within the study area; (2) estimate the abundance and density of rainbow trout vulnerable to the sport fishery within the study area; (3) estimate annual survival of rainbow trout within the study area; (4) compare the current information with the historic information from 1985-87; and (5) monitor the seasonal distribution of rainbow trout. Secondary objectives were to describe the length and age compositions of Arctic grayling (*Thymallus arcticus*) and Dolly Varden (*S. malma*) incidentally captured within the study area.

STUDY AREA

The Kanektok River originates at Kagati Lake in the Refuge and flows west approximately 150 km before entering Kuskokwim Bay at the village of Quinhagak (Wagner 1991) (Figure 1). The drainage is approximately 2,357 km^2 with the upper 117 km of the river occurring within the Refuge. The river is extremely braided with many unstable, newly cut channels and has a predominantly gravel bottom for most of its course. The velocity of the river is swift, averaging 1.4-1.7 m/sec. Most of the riparian area has thick stands of willow (*Salix* spp.) and alder (*Alnus* spp.) with scattered stands of cottonwood (*Populus* spp.). Major tributaries of the river are Takshilik, Nukluk, Klak, Kanuklik and Paiyun creeks.

The study area in 1993 was restricted to the same 32 km section of the mainstem river sampled during 1985-1987. The area extended from km 28 (the lower boundary of the wilderness area) upstream to km 60. In 1985 the study area was chosen because it included suitable habitat for rainbow trout, and it was within the wilderness area of the Refuge (Wagner 1991). The lower reach of the study area (km 28-37) is highly braided with no obvious main channel, the middle reach (km 38-47) is also braided but usually contains a main channel, and the upper reach (km 48-60) is less braided, often bordered by bluffs. The only tributary within the study area that was sampled was the lower five km of Clear Creek, a tributary that enters the river in the upper reach at approximately km 51.

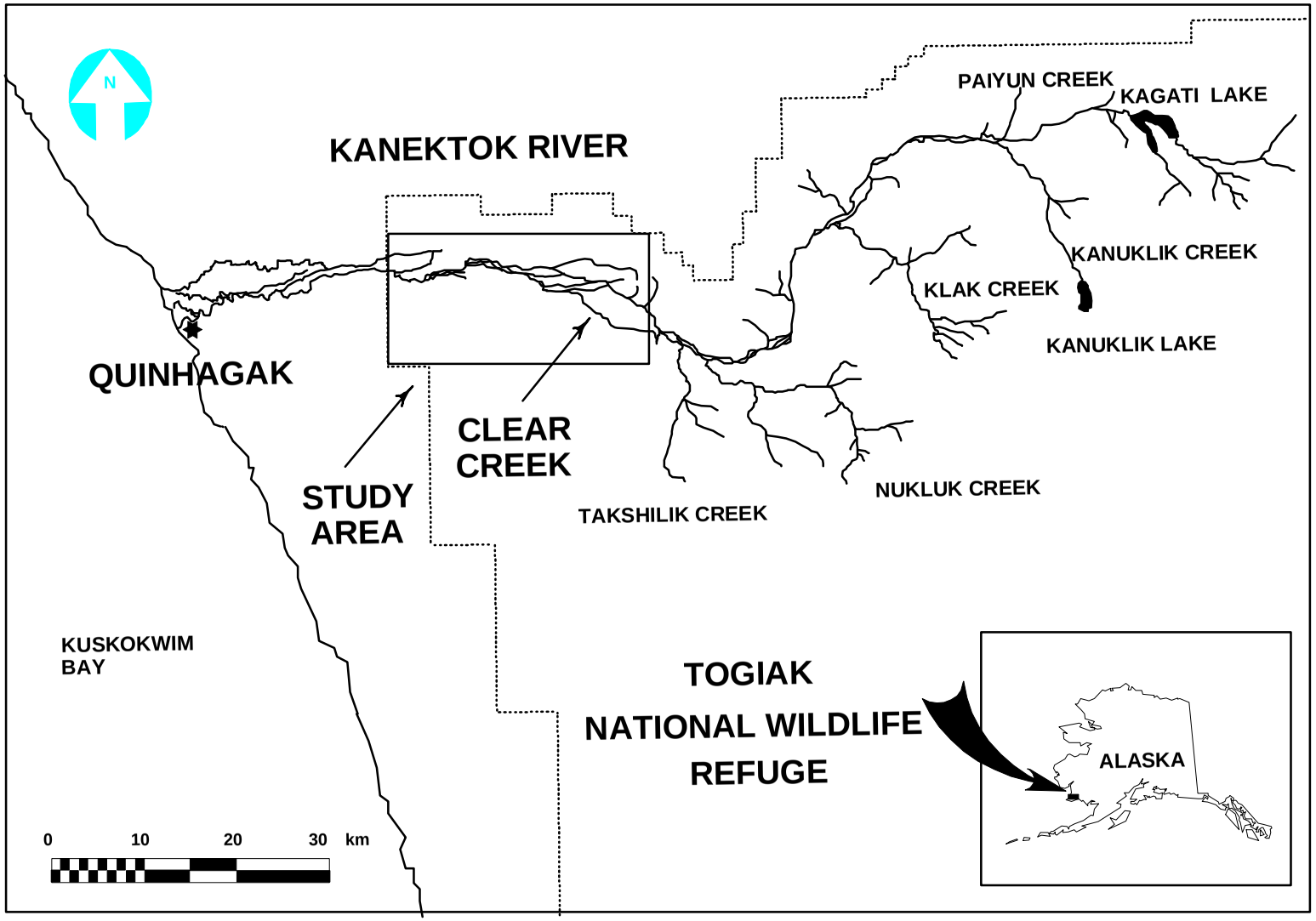

Figure 1.-Study area for rainbow trout projects on the Kanektok River, 1985, 1986, 1987, and 1993,

METHODS

Length, Age, and Survival

The study in 1993 was designed to replicate the sampling of rainbow trout conducted in 1985-1987. The study area was stratified into four 8 km sections with each section equally sampled in systematic order. In 1985-1987 fish were captured by hook and line with single hook artificial lures. In 1993 fish were captured in the same manner. In 1985 rainbow trout were sampled within the study area during four raft trips. During 1986, 1987, and 1993 outboard jet motor boats were used as transport throughout the study area. Rainbow trout were sampled from 11 July to 10 September, 1985; 22 May to 2 September, 1986; 10 June to 7 September, 1987; and 20 June to 13 September, 1993.

Fork length (mm) was recorded for all captured rainbow trout. Due to gear selectivity against small fish, length distributions were truncated to include only fish $\geq$ 200 mm. Cumulative length frequency distributions for all years were compared with a Kolmogorov-Smirnov two sample test ($\alpha = 0.05$) (SYSTAT for Windows 1992). Because sampling times varied among years, analysis of length among the years was restricted to data from fish captured during a sampling period common to all years (11 July to 2 September).

Scales from rainbow trout $\geq$ 200 mm were collected from the preferred scale area (Jearld 1983) and aged according to Koo (1962). In 1985 scales were systematically collected from 50% of the rainbow trout captured. In 1986 two thirds of the rainbow trout were systematically subsampled for scales. In 1987 and 1993 scales were collected from all rainbow trout captured. Scales were not collected from recaptured rainbow trout. In 1985, 1986, and 1993 ages were interpreted by two readers and disagreements resolved by conference. In 1987 age was designated as the modal age among estimates from three readers. Regenerated scales were discarded. Within each year the age distributions of fish captured before and after the common period were compared to the age distribution from the common period with X^2 tests of independence ($\alpha = 0.05$) (SYSTAT for Windows 1992). Age distributions from the common period for all years were also compared with X^2 tests of independence ($\alpha = 0.05$) (SYSTAT for Windows 1992). To ensure that the number of cells with expected frequencies > 5 was > 80% (Santner and Duffy 1989), ages 2 and 10 were excluded from the X^2 analyses.

Annual survival estimates were calculated for each year from catch curve analysis using a constant survival and constant recruitment model (Everhart and Youngs 1981). The model used only the ages of fully recruited rainbow trout captured during the common sampling period. The first year beyond the modal age of the catch curve was considered the youngest fully recruited age (Ricker 1975).

Sample sizes from Clear Creek were small in all years, and data concerning length, age, and survival from this stream were deleted from analyses.

Abundance Estimate

In 1993 project personnel marked rainbow trout ≥ 300 mm with numbered anchor tags (Floy Tag and Manufacturing, Seattle, WA). The adipose fin was clipped as a secondary mark to assess tag loss. Using subsamples of marked and recaptured fish, an abundance estimate was attempted with the Chapman modification of the Petersen two sample closed population model. The marking portion of the study occurred from 8-20 July; the recapture portion from 5-19 August.

Equal capture probability and equal mixing of tagged and untagged fish among river sections were tested with X^2 tests of independence ($\alpha = 0.05$) (SYSTAT for Windows 1992). Equal probabilities of capture by length were tested with two sample Kolomogorov-Smirnoff tests ($\alpha = 0.05$) (SYSYAT for Windows 1992).

Movement

Radio telemetry.- From 21 August to 12 September 1993, ATS (Advanced Telemetry Systems, Ipsilanti, MN) radio transmitters (model six) were surgically implanted into 24 rainbow trout captured in the study area. In addition, transmitters were implanted into one rainbow trout captured above the study area and one captured below the study area. Transmitters operated in the 40 Mhz range, and individual frequencies were separated by 10 Khz. Transmitters were 78 mm long, 17 mm in diameter, weighed 28 g, and contained loop antennae. Following the criterion of Winter (1983), where transmitter weight should not exceed 2% of fish weight, the smallest implanted fish weighed 1,400 g.

Fish were captured by hook and line and anesthetized to stage 4 (Summerfelt and Smith 1990) with MS-222. Surgical procedures followed Summerfelt and Smith (1990). The gills of each fish were continually bathed with stream water during surgery. After surgery each fish was held upright in gently flowing water to facilitate recovery. Fish were released near the capture site in a protected area of the stream when they were fully recovered.

Implanted fish were monitored with an ATS scanner/receiver from fixed wing aircraft flying at approximately 140 km/h and 300 m above the ground. On each flight the study area was searched a minimum of three times. An area approximately 20 km upstream from the upper boundary of the study area and from the lower boundary to the mouth of the river were searched at least once each flight. During spawning season in spring (late April to early June), the area from Kagati Lake to the study area and the lower portions of the main tributaries in this reach were searched once per flight. From October 1993 to March 1994 relocation of implanted fish was attempted every six weeks. During April through June 1994 aerial tracking was conducted every two weeks. Aerial tracking was conducted monthly during July and August 1994.

The location of each implanted fish was recorded as the location directly beneath the aircraft when the volume of the signal from that transmitter was loudest. Accuracy of the relocation was estimated to be within 1 km of the actual location of the transmitter.

Floy tags.- Fish marked and recaptured during the entire 1993 season were also monitored for movement. Locations and dates of all recaptured rainbow trout were documented.

Arctic grayling and Dolly Varden

Fork length (mm) was measured on all Arctic grayling and Dolly Varden incidentally captured while sampling for rainbow trout during 20 June-13 September 1993. Scales were collected from all Arctic grayling captured and aged with the same methods used for rainbow trout. Otoliths were collected from every fifth Dolly Varden captured. Ages were interpreted by one reader according to Maceina and Betsill (1987).

RESULTS

Length, Age, and Survival

During the common sampling period (11 July-2 September) fork length measurements were collected from 150 rainbow trout ≥ 200 mm in 1985; 131 in 1986; 163 in 1987; and 574 in 1993 (Figure 2). Fork lengths in 1985 ranged from 296-628 mm; 295-640 in 1986; 200-560 mm in 1987; and 213-581 mm in 1993. The cumulative length frequency distributions for 1985 and 1986 were not significantly different (D = 0.11; N_1 = 150; N_2 = 131; P = 0.36) (Figure 3). The remaining comparisons between years were significantly different (D > 0.13; P < 0.03).

Results from X^2 tests of independence indicated that during 1987 and 1993 ages of fish captured before and after the common sampling period were significantly different from ages of fish captured during the common period (X^2 > 14.1; df = 6; P < 0.03). Therefore, only the age distributions from the common period were used for further age analysis.

During the common period in 1985, ages were estimated from 70 of 75 (93%) scale samples; in 1986, 79 of 88 (90%); in 1987, 131 of 163 (80%); and in 1993, 550 of 564 (98%) (Table 1). The remaining scales were unreadable. Ages in 1985 ranged from 3-8 years; 2-9 years in 1986; 3-8 years in 1987; and 3-10 years in 1993. The age distribution from the common period in 1993 was significantly different from the age distributions from the common periods of the remaining years (X^2 = 32.4; df = 18; P = 0.02) (Figure 4). The age distributions from the common periods of 1985, 1986, and 1987 were not significantly different (X^2 = 16.5; df = 12; P = 0.17).

Mean fork length at age for rainbow trout ≥ 200 mm captured during the common sampling period in all years ranged from 210.8 mm at age 3 to 610.0 mm at age 9 (Table 1). The largest rainbow trout captured with readable scales was 628 mm and age 7 in 1985; 615 mm and age 9 in 1986; 560 mm and age 7 in 1987; and 581 mm and age 7 in 1993.

Assuming that the first age class older than the modal age was fully recruited to the sampling gear, rainbow trout from 1985, 1986, and 1987 were fully recruited at age 7 (Figure 4). In 1993 full recruitment to the sampling gear occurred at age 6.

The estimate of survival for age 7 and older rainbow trout was 0.10 in 1985; 0.24 in 1986; and 0.22 in 1987. The survival estimate for age 6 and older rainbow trout from 1993 was 0.42.

Abundance Estimate

Two hundred nineteen rainbow trout were marked and released during the marking phase of the mark/recapture portion of the study. Ten marked and 121 unmarked fish were

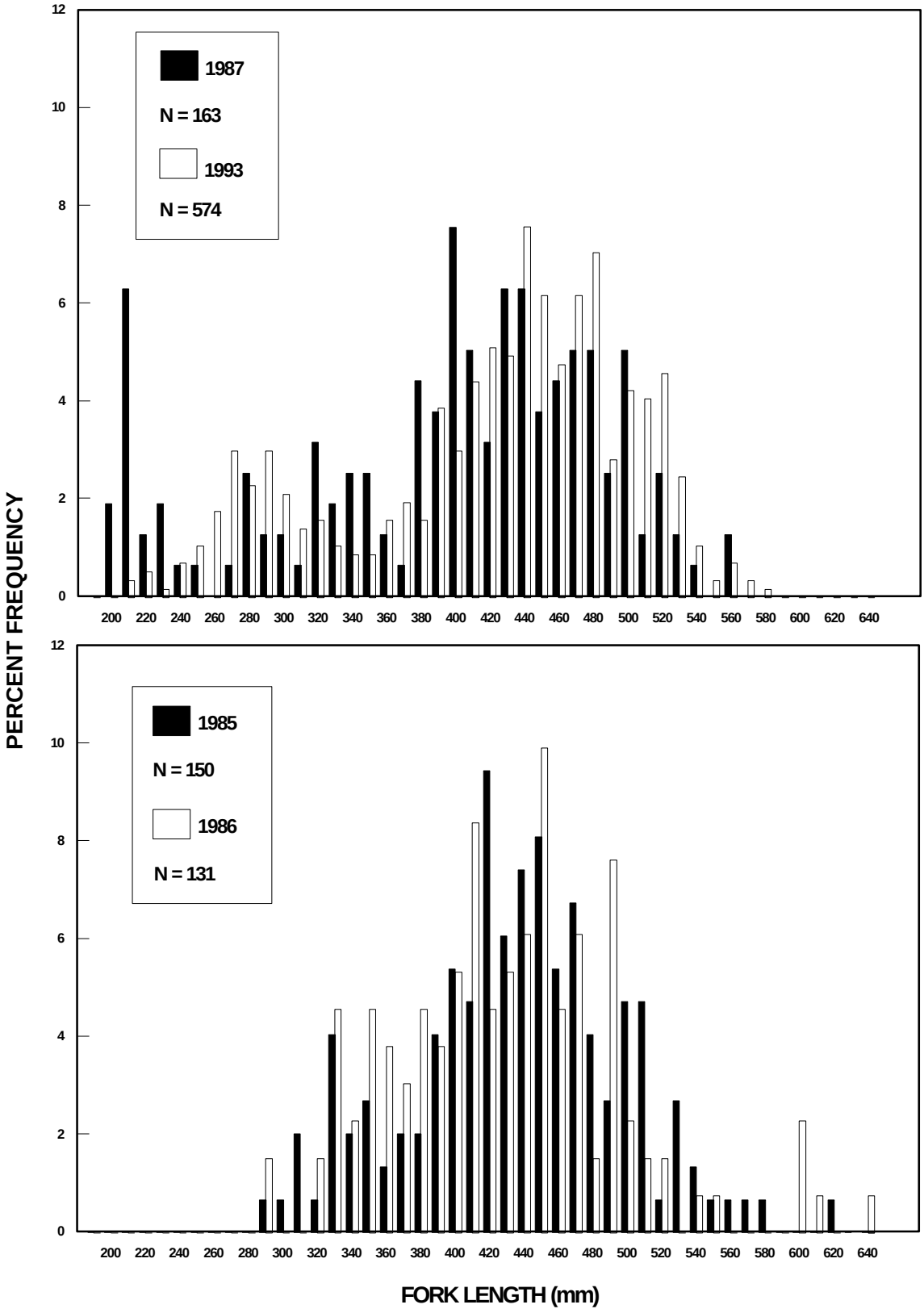

Figure 2.-Fork length frequencies of rainbow trout ≥ 200 mm captured by hook and line between 11 July and 2 September from the Kanektok River, 1985, 1986, 1987, and 1993.

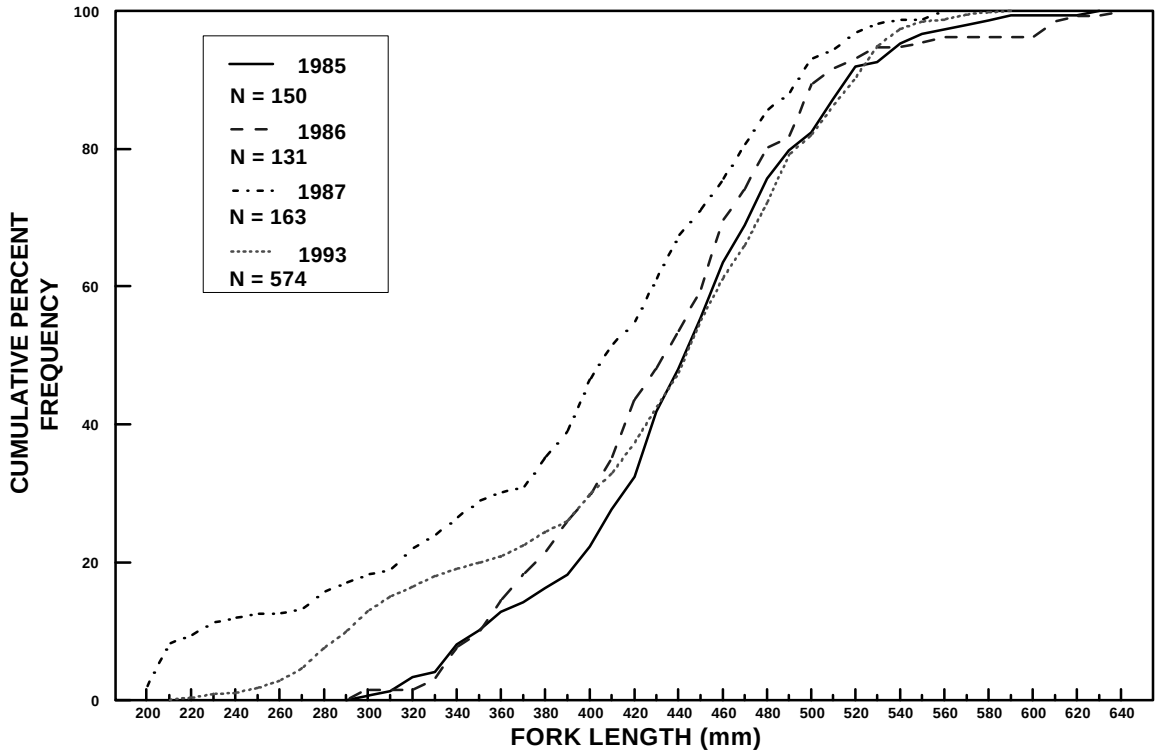

Figure 3.-Cumulative length frequencies of rainbow trout ≥ 200 mm captured by hook and line between 11 July and 2 September from the Kanektok River, 1985, 1986, 1987, and 1993.

Table 1.-Sample sizes, mean fork lengths, at age (FL;mm), and standard deviations of rainbow trout≥200 mm captured by hook and line between 11 July and 2 September from the Kanektok River, 1985, 1986, 1987, and 1993.

	Year											
	1985			1986			1987			1993		
Age	N	FL	SD	N	FL	SD	N	FL	SD	N	FL	SD
2	0	-	-	1	333.0	0.0	0	-	-	0	-	-
3	2	334.5	16.5	3	309.0	16.4	16	210.8	8.6	82	283.6	28.4
4	12	352.3	30.3	11	361.5	20.5	15	293.9	26.1	67	362.8	58.5
5	17	396.2	53.0	20	389.2	39.9	22	373.0	47.2	128	427.3	35.9
6	20	444.0	36.7	21	438.3	32.3	48	418.6	39.8	124	461.5	35.5
7	17	491.5	44.2	18	491.9	45.2	23	473.2	47.2	105	489.8	36.7
8	2	496.5	43.5	3	502.3	35.9	6	468.3	31.4	38	510.4	31.6
9	0	-	-	2	610.0	5.0	1	457.0	0.0	5	521.4	13.1
10	0	-	-	0	-	-	0	-		1	502.0	0.0
Total	70			79			131			550		

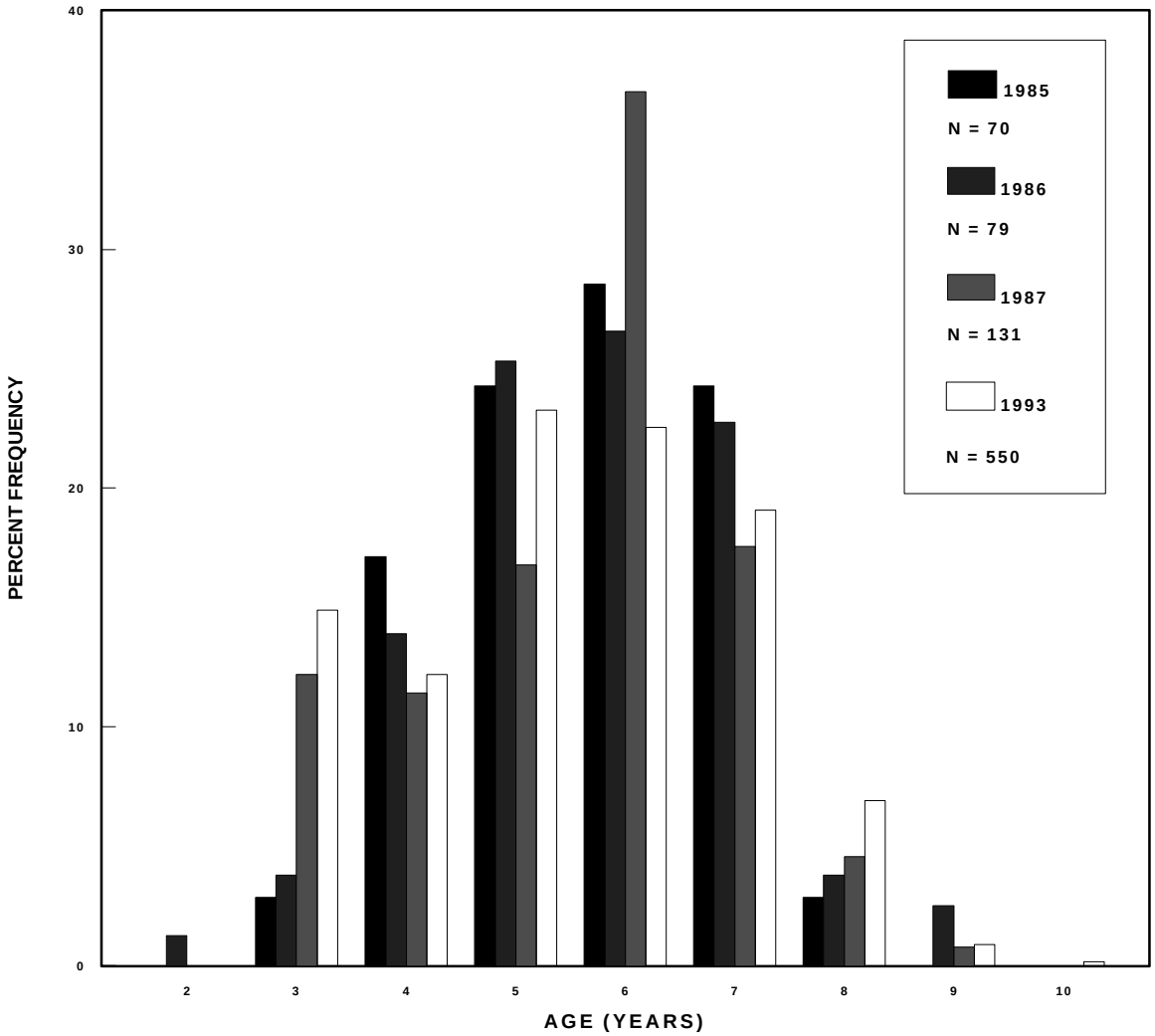

Figure 4.-Age frequencies of rainbow trout ≥ 200 mm captured by hook and line between 11 July and 2 September from the Kanektok River, 1985, 1986, 1987, and 1993.

captured during the recapture phase. During the marking phase fish ranged in length from 307-545 mm and during the recapture phase from 301-580 mm. Lengths of recaptured rainbow trout ranged from 358-528 mm. Therefore, data sets were truncated to include only rainbow trout ≥ 358 mm. There was no evidence of tag loss.

The small number of recaptured rainbow trout did not allow meaningful testing of the assumptions of equal mixing or equal probability of capture by length. Therefore, an abundance estimate could not be generated.

Movement

Radio telemetry.- Transmitters were implanted in 19 rainbow trout captured in the mainstem river. Additionally, transmitters were implanted in seven rainbow trout captured in the lower five km of Clear Creek. Fork lengths of the fish receiving transmitters ranged from 479-572 mm; weights from 1,400-2,150 g; and ages from 5-10 years. Of the 26 radio-tagged fish, 2 were relocated only twice early in the study, and it was assumed their transmitters had failed. Also, one fish apparently died or expulsed its transmitter. These three fish were excluded from the study, and movements of 16 fish implanted in the mainstem river within the study area, six from Clear Creek, and one from above the study area were analyzed. Flights during November and February were postponed due to poor weather and equipment malfunction, and 13 flights were actually conducted. The number of relocations for an individual fish ranged from 6-12, and the number of fish relocated per flight ranged from 2-23. During the first flight, 60% of the relocated fish were detected within 2 km of their implantation sites. Of the remaining fish, equal numbers moved upstream or downstream from their release sites. There appeared to be no damaging effects from surgery.

Throughout the movement study, most of the rainbow trout with transmitters moved 10 km or less from their release sites (Table 2 and Appendix A). The maximum movement measured was 36 km by one fish that moved from km 5 of Clear Creek to km 20 of the Kanektok River during fall 1993 and then returned 34 km upstream to three km above the confluence with Clear Creek during winter 1993-spring 1994. The minimum movement measured was exhibited by two fish that remained within 3 km of their release sites throughout the study.

Nearly three quarters of the radio-tagged rainbow trout were always relocated within the study area. Six fish were relocated at least once downstream of the study area, and one fish was relocated upstream of the study area. The fish that was implanted upstream of the study area remained in that same area for most of the relocations.
Twenty rainbow trout were relocated during October 1993 and only one fish moved more than 10 km from its release site. While most of the fish implanted within the mainstem river remained in the river, two fish moved into Clear Creek.

By December 1993 all 23 radio-tagged fish were relocated in the mainstem river. During winter, two rainbow trout were consistently relocated below the study area between km

Table 2.-Number of radio-tagged rainbow trout and their maximum movements in the Kanektok River from implantation sites during August-September 1993 to aerial relocation sites during fall 1993-summer 1994.

	Movement (km)			
Relocation season	1-10	11-20	21-30	>30
Fall[a]	19			1
Winter[b]	21	1	1	
Spring[c]	16	3	3	1
Summer[d]	18	1		1

[a] Fall = October 1993 (November flight cancelled).
[b] Winter = December 1993 to mid April 1994.
[c] Spring = late April to early June 1994.
[d] Summer = late June to August 1994.

24-26; six rainbow trout were consistently relocated between km 32-40; and fourteen rainbow trout were consistently relocated between km 43-56. The remaining fish was usually relocated upstream of the study area. Throughout the remainder of the winter, only four fish moved more than 10 km from the locations occupied in December.

During spawning season (late April-early June) 23 fish were relocated. Three fish were consistently relocated between km 34-40. These three fish had overwintered between km 32-40, and all were implanted with transmitters in the lower half (km 28-44) of the study area. Eleven fish were consistently relocated between km 43-56, and all had overwintered with this same reach. Also, all had been released in the upper half (km 45-60) of the study area, including four from Clear Creek. Three fish were consistently relocated between km 21-27. The remaining radio-tagged fish were scattered throughout the river from km 24-70. Only seven of the 23 moved more than 10 km from their overwintering locations. No radio-tagged fish were relocated in tributaries.

Twenty fish were relocated during summer 1994. By mid-August, all but two fish were within 10 km of the site where they had been released the year before. Only five fish were relocated more than 10 km from the sites they occupied during spawning season.

Floy tags.- Fifty-five individual rainbow trout were recaptured during the study (Table 3 and Appendix B). Fork lengths and ages of recaptured fish ranged from 358 mm and age 4 to 548 mm and age 10. Only two fish were recaptured more than 10 km from their original capture site. Thirty-three fish were recaptured at their original tagging location. None of these fish were captured or recaptured outside the study area.

Table 3.-Number of Floy-tagged rainbow trout and their movements in the Kanektok River from capture sites during June-August 1993 to recapture sites during July-September 1993.

	Movement (km)	
Recapture month	1-10	11-20
July	22	1
August	24	1
September	7	

Arctic grayling and Dolly Varden

Thirty-five Arctic grayling and 181 Dolly Varden were incidentally captured during 1993. Ages of Arctic grayling ranged from 3-7 years, and no scales were regenerated (Table 4). Ages from 38 Dolly Varden ranged from 4-10 years. Mean fork length at age for Arctic grayling ranged from 267 mm at age 3 to 414 mm at age 7; and from 366 mm at age 4 to 551 mm at age 10 for Dolly Varden. Fork lengths of Arctic grayling ranged from 267-443 mm (Figure 5) and from 216-629 mm for Dolly Varden (Figure 6). Arctic grayling and Dolly Varden were captured throughout the sampling season.

Table 4.-Mean fork lengths at age (FL; mm), standard deviations, and sample sizes for Arctic grayling and Dolly Varden captured by hook and line from the Kanektok River, 1993.

	Arctic grayling			Dolly Varden		
Age	FL	SD	*N*	FL	SD	*N*
3	267		1			
4	342	17	3	366	59	5
5	372	5	14	367	17	11
6	394	5	11	443	19	11
7	414	8	6	495	27	6
8				488	31	3
9						
10				551	12	2

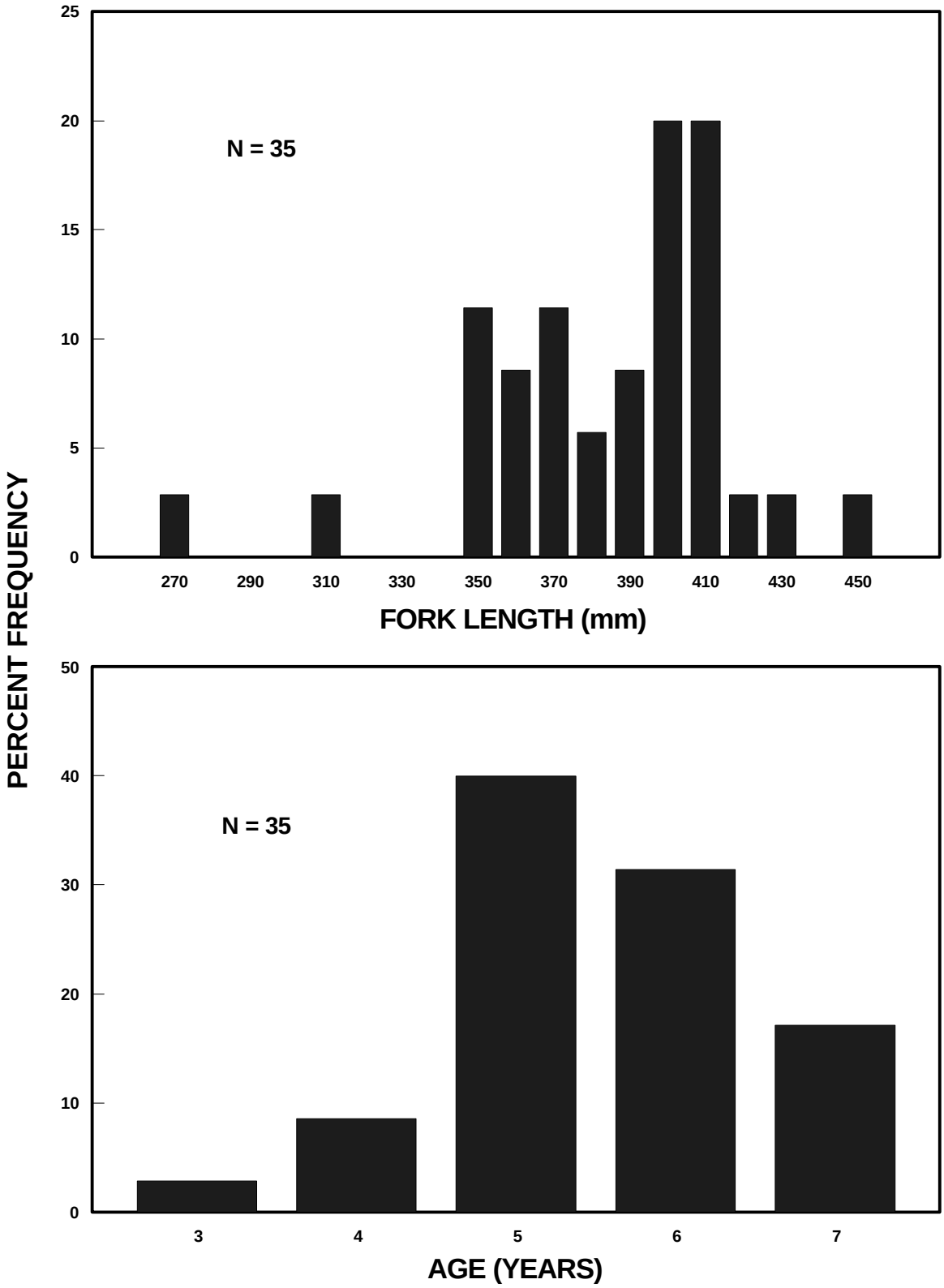

Figure 5.-Length and age frequencies of Arctic grayling captured by hook and line from the Kanektok River, 1993.

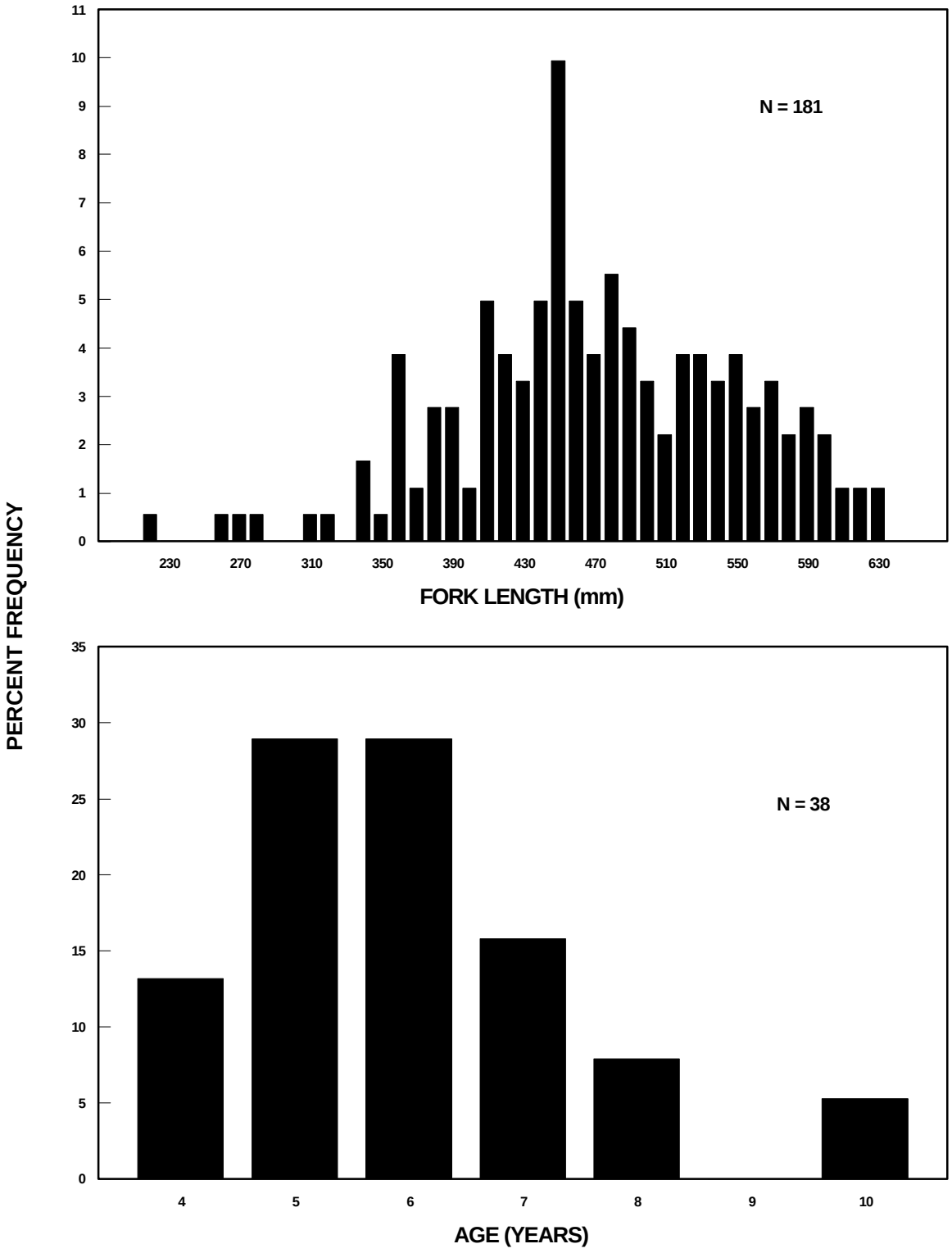

Figure 6.-Length and age frequencies of Dolly Varden captured by hook and line from the Kanektok River, 1993.

DISCUSSION

The Refuge Comprehensive Conservation Plan (U.S. Fish and Wildlife Service 1986) and Fishery Management Plan (U.S. Fish and Wildlife Service 1990) require that fish and wildlife populations on the Refuge be conserved in their natural diversity, including natural size and age diversity. The Department's Southwest Alaska Rainbow Trout Management Plan (Alaska Department of Fish and Game 1990a) requires rainbow trout populations to be managed to maintain historic size and age structures. These two plans guide a management approach that provides for optimal fishing opportunity while conserving the historic size and age compositions of the population.

Length, Age, and Survival

The significant differences in length frequency distributions from the common period among the years were mostly due to the capture of a large proportion of small (< 300 mm) rainbow trout in 1993 and an even larger proportion in 1987. Whether the capture of greater proportions of small rainbow trout during 1987 and 1993 was due to greater cohort strength, immigration during sampling, or selective natural mortality of small fish in 1985 and 1986 is unclear. The significant differences may also be partially attributed to the absence of large (> 600 mm) rainbow trout in 1987 and 1993.

The absence of large rainbow trout during the common period in 1987 and 1993 is a major concern for management of this population. However, during sampling that occurred before the common period in 1987, two rainbow > 600 mm were captured. Although sampling occurred before and after the common period in 1993, no fish larger than 581 mm was captured. Total sample sizes for fish ≥ 200 mm in 1985-87 including sampling before, after, and during the common period were 299, 530, and 343, respectively, with a total of two, seven, and two fish > 600 mm captured. Total sample size for 1993 was 827. With such a large sample size in 1993 the expectation would have been to capture several large fish. The absence of fish > 600 mm in 1993 indicates that the size structure of the population may be changing and may no longer be at historic levels.

The significant difference between age distributions from 1985-87 and 1993 appeared to be mostly attributable to larger proportions of age 3 and age ≥ 8 fish captured during 1993. The larger proportion of age 3 fish corresponds to the larger proportion of small fish captured in 1993. The reason for the larger proportion of older fish in 1993 is unclear. The significant difference in age distributions may also have been partially due to a change in age at full recruitment from 1985-87 to 1993.

The change in age at full recruitment is also a major concern for management of this population. Age at full recruitment was consistent at age 7 for 1985-87, but in 1993 full recruitment decreased to age 6. Assuming constant recruitment, age at full recruitment would have been expected to occur at age 7. Although age 5 contained only four (0.7%) more fish than age 6, the similar frequencies in both these age classes indicated that age 5 fish were larger and more susceptible to the sampling gear than fish of the same age in 1985-87. Although mean length at age did not change appreciably from 1985-87 to 1993,

the significant difference in age distributions and younger age at full recruitment suggests that the age structure may be changing from historic levels.

The estimates for survival in 1986 and 1987 were very similar, but in 1985 it was considerably less. The sample from 1985 did not include fish older than age 8 while samples from 1986 and 1987 included age 9 fish. Survival in 1993 was considerably higher than the other years because the estimate in 1993 contains an additional age class (age 6) due to younger age at full recruitment. However, age class 5 contained only 4 (0.7%) more fish than age class 6. If ages 5 and 6 are considered equal, age at full recruitment occurred at the same age (age 7) as in 1985-87. By applying age 7 to the estimate for 1993, survival is 0.26 and very similar to the estimates in 1986-87. Although the survival model assumes constant recruitment and mortality, age at full recruitment appears to have changed slightly since 1987, and this assumption may have been violated. However, the estimates remain valuable as indices of survival rates.

Although data among the years were standardized to limit variability, sampling bias may have affected the outcomes of length, age, and survival analyses. Hook and line sampling has been the accepted method for evaluating most rainbow trout populations in southwest Alaska, but the variability within this gear may not provide a clear representation of population structure. Variability in the sampler's angling experience and gear selection and a fish's previous experience with the gear may all affect the number of fish captured as well as the length and age composition of the sample. During the common period, hook and line sampling in 1985-87 resulted in small sample sizes for length distributions and subsampling for age in 1985-86 further decreased the size of the samples. In all years sample sizes for some age classes were extremely small. These small sample sizes may not have reflected the actual status of the population.

Interpretation of ages from rainbow trout scales is problematic and may also have affected the results of the study. Scale ages from rainbow trout are subject to error because slow growth produces compressed circuli with indistinct annuli, scale margins are resorbed during spawning, and annuli often do not form during the first winter (Lentsch and Griffith 1987). Also, variability of age estimation within reader and between readers can effect the outcomes of age composition analysis (Coggins 1994). Therefore, scale ages must be interpreted conservatively. These factors undoubtedly had an effect on the differences in age distributions and mean length at age. However, a reexamination of a subset of scales from all years indicated that the assignment of ages was consistent among samples.

The absence of fish > 600 mm in 1993, the significant difference in age frequencies between 1985-87 and 1993, and the change in age at full recruitment indicate that its population structure may be changing. These apparent changes may be due to natural variation or may be from effects of sampling and analysis, but fishing activities such as subsistence harvest, sport harvest, and hooking and handling mortality from catch and release sport fishing may also have affected the population.

Subsistence harvest has not been characterized, and the magnitude of its rainbow trout fishery is unknown. Most subsistence fishing during the open water season targets Pacific

salmon (*O.* spp.) and occurs close to the village of Quinhagak well below the study area (Mark Lisac, U.S. Fish and Wildlife Service, personal communication). Subsistence ice fishing within the study area does occur, but its effort, catch, and harvest are also unknown.

Although there are no data concerning the sport harvest of rainbow trout within the study area, estimates for the entire river indicate that it is minimal. During 1986-1993 effort for all sport species peaked in 1988 (12,697 angler days) and since 1989 has decreased and stabilized at approximately 25-40% of the 1988 level (Mills 1987-94). The first and highest estimates of catch (7,180) and harvest of rainbow trout (281) were in 1990 (Mills 1991-94) when the Board enacted the current regulations. Since then catch has ranged from 19-75% and harvest from 20-65% of the 1990 levels. Harvest from 1990-93 has comprised 3.1-3.7% of the catch, ranging from 55-281 rainbow trout per year. With effort estimated for all sport fisheries, and catch and harvest of rainbow trout estimated for the entire river, it is doubtful that sport harvest within the study area would have been sufficient to affect the population. However, prior to 1990 harvest is unknown and may have been sufficient to affect the historic size and age compositions.

As noted with the low harvest rate, most sport anglers on the Kanektok River voluntarily practice catch and release fishing for rainbow trout. Although the Board also instituted gear restrictions in 1990 to limit hooking mortality within the wilderness portion of the river, hooking and handling mortality from catch and release fishing may be a factor affecting the population structure. Researchers have reported mortality rates from 0.3% in single capture wild cutthroat trout (*O. clarki*) (Schill et al. 1986) to 72% in air exposed exhaustively exercised laboratory rainbow trout (Ferguson and Tufts 1992), but most studies indicate a mortality rate of approximately 3-12% (Taylor and White 1992). By applying the 3-12% rate to the catch estimates for the entire river from 1990-1993 (Mills 1991-1994), approximately 45-937 rainbow trout per year could have died due to hooking and handling mortality. With the addition of harvest, estimated mortality from sport fishing ranged from approximately 100-1,218 rainbow trout per year. Although these values apply to the entire river, the effects over several years may have been sufficient to alter the size and age structures of the population within the study area. Hooking and handling mortality may have been particularly significant prior to 1989 when effort was 2-3 times the levels from 1989-93.

Large fish are generally preferred by anglers (Ontario Ministry of Natural Resources 1983), and large fish are more susceptible to death from hooking and handling mortality (Taylor and White 1992). These two selective factors in combination with harvest may have provided sufficient influence over several years to cause the absence of rainbow trout > 600 mm in 1993. The absence of large fish may also have influenced the change in age at full recruitment. Removal of the large fish may have reduced intraspecific competition and allowed fish to recruit to the sampling gear at a younger age (Ontario Ministry of Natural Resources 1983). Recruitment of younger fish to the gear suggests that compensatory growth may be occurring (Healey 1978).

Abundance Estimate

The large size of the Kanektok River makes efficient sampling for abundance estimates very difficult, and sufficient numbers of marked rainbow trout could not be recaptured in 1993. Based on a preliminary abundance estimate of approximately 20,000 rainbow trout > 300 mm in the study area (Wagner 1991), a Petersen estimate would require a minimum of 1,400 fish to be handled; 500 fish marked during the marking event and a minimum of 900 fish examined during the recapture event (Krebs 1989). The total catch of rainbow trout within the study area by a 2-3 person crew during June-September 1993 was 827, slightly more than half the required sample size. Other estimators (Schnabel, Jolly-Seber) may be more appropriate for estimation of rainbow trout abundance in the Kanektok River, but future sampling must consider expending more effort, expanding the sampling season, or reducing the size of the study area.

Movement

Resident rainbow trout are generally not known for extensive travel (Cargill 1980; Morrow 1980). Although some radio-tagged rainbow trout in the Kanektok River exhibited considerable upstream and downstream movements among seasons in 1993-94, the majority of these fish did not move substantially during any season. During July-September 1993 Floy-tagged rainbow trout did not move substantially either. In contrast, populations of rainbow trout from two lake systems in southwest Alaska have exhibited considerable movement. Floy-tagged fish from the Kvichak River were recaptured between years in the Copper River, approximately 80 km across Lake Iliamna (Minard et al. 1992). Radio-tagged rainbow trout moved approximately 50 km from an overwintering area in the Naknek River to summer feeding areas in the Bay of Islands of Naknek Lake (Burger and Gwartney 1986). However, these populations are associated with large lake systems that may require considerable movement to reach spawning, feeding, and overwintering areas.

The assignment of dates for relocation of radio-tagged fish was arbitrary, but it did demonstrate movements of fish in response to seasonal demands. Because all radio-tagged fish, including fish implanted in Clear Creek, were relocated in the mainstem river during spring, tributaries did not appear to be important spawning areas. The information from recaptured Floy-tagged fish indicated that the study area is important to rainbow trout during summer. Additionally, information from radio-tagged fish indicated that the study area is important for spawning and overwintering. Movement information applies only to fish of similar size and age as those recaptured and relocated in the study. Smaller fish may exhibit different movements.

Arctic grayling and Dolly Varden

Fork lengths and ages of Arctic grayling and Dolly Varden from the Kanektok River in 1993 were typical for these species in Alaska (Morrow 1980). Also, hook and line sampling of the river by the Department yielded 34 Arctic grayling in July 1975 (Coggins

1992) and the Office captured 46 Arctic grayling with hook and line in July 1983 (Dlugokenski et al. 1983). Lengths and ages from 1975 were similar to those from Arctic grayling captured during 1993 and ranged from 257-463 mm and 4-9 years. Data from 1983 were available only by 25 mm length classes, and fish were captured in all classes from 300-500 mm. Ages were not estimated in 1983. Any differences in length or age among the sampling years may have been due to sampling duration, timing, or location.

In 1983 the Office captured 64 Dolly Varden by hook and line in the Kanektok River (Dlugokenski et al. 1983). These data were available only by 25 mm fork length classes. The smallest Dolly Varden captured was within the 400 mm class and the largest was within the 675 mm class. Any differences in lengths between 1983 and 1993 were probably due to similar reasons as described for Arctic grayling. Ages of Dolly Varden were also not estimated in 1983.

Several life history strategies are exhibited by Dolly Varden in Alaska including stream resident and anadromous forms (Armstrong and Morrow 1980). While anadromous Dolly Varden may exist in the Kanektok River, the presence of Dolly Varden at the beginning of the sampling season indicates that some fish are resident.

Conclusions and Recommendations

While the data are not conclusive and any changes in population structure would be subtle, the absence of fish > 600 mm in 1993 and the associated younger age at full recruitment should serve as a warning that the historic length and age composition of rainbow trout in the study area may be changing. Subsistence and sport harvest within the study appear to be minimal, but hooking and handling mortality from catch and release fishing may be a major factor. Because rainbow trout exhibited limited movement during the summer, these fish may be vulnerable to capture several times during a season. With the previous higher effort and possibility of multiple captures, hooking and handling mortality may have been sufficient to affect the population, especially the portion with larger fish.

While guided use within the Refuge has been capped at 1984 levels, unguided use within the Refuge has increased during recent years (Mark Lisac, U.S. Fish and Wildlife Service, personal communication). To fulfill the mandate of the Refuge Comprehensive Conservation and Fishery Management plans to conserve natural diversity and to also fulfill the mandate of the Department's Southwest Alaska Rainbow Trout Management Plan to maintain historic size and age structure, it is recommended that conservative management of the population be continued and that public use not be increased above current levels. Because radio-tagged rainbow trout did not exhibit movement into tributaries during spring, there appears to be little potential for overharvest in these areas during the spawning season.

To further describe the status of rainbow trout within the study area and assess the effects of its fisheries, the following actions are recommended: (1) sample every three years for length, age, and abundance as part of a long term monitoring program; (2) with the help of the Refuge river rangers, determine the effort, catch, and harvest of rainbow trout by

subsistence and sport fisheries within the study area; (3) continue to annually monitor use on the entire river through special use permits and the statewide harvest survey; (4) determine the incidence and effects of hooking and handling mortality on rainbow trout; (5) to minimize hooking and handling mortality, implement a program to educate sport anglers on proper methods of catch and release fishing; and (6) continue to monitor Arctic grayling and Dolly Varden populations as part of the rainbow trout studies.

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APPENDIX

Appendix A.-Aerial relocations (km) of radio-tagged rainbow trout from the Kanektok River 1993-94 (all transmitters were implanted from 21 August-13 September 1993; CCX = location in Clear Creek; CC0 = mouth of Clear Creek).

		Relocation (km)			
Frequency	Implant Locationt	Fall[a]	Winter[b]	Spring[c]	Summer[d]
40.06	29	24	24-26	24	27
40.26	32	34	32-35	34-35	34
40.08	34	32	35-38	34-35	32-34
40.28	35	35	35-37	35-59	38
40.31	35	34	34-35	21-27	21
40.33	42	38	35-37	37-40	37-38
40.35	46	46	24	24	-
40.37	48	CC5	45-48	48-53	CC0-CC2
40.17	51	51	43-45	43-48	42-45
40.19	51	46	48-51	51	50
40.21	51	CC5	48-50	48-53	50
40.10	53	56	43-46	50-56	54-56
40.13	53	-	53-54	26-54	54-56
40.15	53	53	56	54-56	54-56
40.23	53	53	53	54-56	59-60
40.41	54	56	50	24-48	21
40.59	64	-	58-70	59-70	66-
40.47	CC0	-	46-50	46-48	46
40.51	CC0	CC0	43	50	45-46
40.39	CC5	CC5	38-40	37-CC2	CC2
40.53	CC5	CC3	46-50	43-50	-
40.55	CC5	20	46-48	48-54	-
40.57	CC5	CC2	56	48-62	CC0-CC2

[a] Fall = October 1993 (November flight cancelled).
[b] Winter = December 1993 to mid April 1994.
[c] Spring = late April to early June 1994.
[d] Summer = late June to August 1994.

Appendix B.-Capture and recapture dates and sites for Floy-tagged rainbow trout in the Kanektok River, 1993 (CCX = location in Clear Creek; CCO = mouth of creek).

	Initial capture		Recapture location by month		
Tag number	Date	Location (km)	July	August	September
1504	24 June	34	35	-	-
1505	24 June	38	38	-	-
1601	25 June	34	34	-	-
1506	25 June	40	40	-	-
1567	26 June	46	-	48	-
1562	26 June	46	-	46	-
1509	26 June	CC2	CC2	-	-
1568	26 June	46	-	46	-
1569	26 June	50	43	-	-
1537	28 June	53	53	-	-
1574	28 June	53	48	-	-
1536	28 June	53	53	-	-
1550	1 July	40	38	-	-
1523	2 July	CC2	CC2	-	-
1678	2 July	CC5	CC5	-	-
1659	2 July	CC0	-	-	CC0
1654	2 July	CC0	-	CC0	-
1585	2 July	CC3	-	43	-
1590	4 July	29	-	34	-
1672	5 July	42	-	42	-
1692	6 July	52	51	-	-
2003	6 July	51	51	-	-
1700	8 July	51	-	51	-
1695	8 July	52	34	-	-
2029	9 July	53	53	-	-
2011	9 July	59	-	59	-
2021	9 July	54	-	-	54
2041	11 July	40	-	38	-
2130	12 July	51	50	-	-
2079	12 July	46	-	45	-
2143	15 July	53	-	53 & 53	-
2110	15 July	54	-	56	-
2113	15 July	54	54	-	-
2141	15 July	54	58	-	-
1609	16 July	32	32	-	-
2146	16 July	32	30	32	-
2179	16 July	34	-	32 & 34	-
2155	17 July	40	-	37	-
2153	17 July	40	-	42	-
2204	17 July	45	-	45	-
2241	19 July	56	-	53	-

Appendix B.-Continued.

	Initial capture		Recapture location by month		
Tag number	Date	Location (km)	July	August	September
2244	19 July	53	53	-	-
1610	20 July	35	-	37	-
2292	22 July	35	35	-	-
2331	23 July	51	-	51	-
2310	25 July	51	53	-	-
2309	25 July	51	-	-	51
2316	26 July	35	-	37	-
2387	30 July	50	-	48	-
2373	30 July	46	-	46	-
2526	30 July	46	-	-	46
2528	31 July	53	-	53	-
2771	16 August	CC3	-	-	CC3
2410	16 August	CC3	-	-	CC3
2406	16 August	51	-	-	51